CHEMICAL CHANGES OCCURRING DURING THE GROWTH OF DIPLOID AND TETRAPLOID DATURA STRAMONIUM

BY

MARTIN GIBBS

B.S., Philadelphia College of Pharmacy and Science, 1943

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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IN THE GRADUATE SCHOOL OF THE
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CHEMICAL CHANGES OCCURRING DURING THE GROWTH OF DIPLOID AND TETRAPLOID *DATURA STRAMONIUM*

Introduction

Physiological investigations of polyploid material have been recently the subject of much research. Work of this type leads to information about the physiological changes resulting from an increase in chromosome number.

Because the results have shown no constant pattern, very few general conclusions can be derived from the collected data. No clear understanding has been reached as to the nature and extent of physiological changes accompanying polyploidy and their significance in the life cycle of the polyploid plant. This lack of agreement may be due to the failure of comparing the diploid and tetraploid plants at comparable stages of development. Because the tetraploid develops more slowly, chronological age of the diploid and tetraploid is not necessarily equal to the physiological age. Most workers believe that the slower growth rate and the higher water content of the polyploid is a large factor causing the differences between the normal and polyploid plant, when both types of plants are compared on a chronological and physiological age basis.

This study was undertaken in order to compare the changes in the chemical composition of diploid and tetraploid *Datura stramonium* plants during their growth. This comparison was made on the basis of both the physiological and chronological age of the material. The material was collected on a physiological basis, that is, collections were made at the time of appearance of an equal number of leaves regardless of the chronological age.

Experimental

Diploid and tetraploid *Datura stramonium* L. were grown in pots of glazed clay construction which were weighed every other day, with water added to keep the soil moisture constant. Samples were collected when the plants had four, six, ten, eleven, eighteen, nineteen and twenty leaves. An additional diploid cutting was made when the diploid plants had three leaves. The plants were separated into stem, which included petioles and pedicels, leaves, cotyledons and inflorescence. The following data were obtained: fresh weight, dry weight, water content, calcium, magnesium, potassium, iron, total nitrogen, nitrate, phosphorus, silica, reducing sugar, total sugar and non-fermentable sugar. The data were calculated on a percentage basis and on an absolute basis and plotted against age in days (chronological age basis) or leaf number (physiological age basis). All analytical results were reported on the basis of oven-dry weight.

Results and Conclusions

1. The outstanding characteristic of the polyploid plants was their slower rate of physiological development as compared to that of the diploids. The diploid plants took 35 days to complete their vegetative phase of growth while the tetraploid plants needed 50 days to accomplish the same. Thus, at equal chronological ages, the tetraploid plants were physiologically younger than the diploid plants. The slower rate of development of the tetraploid plants probably explains most of the differences in the chemical composition of diploid and tetraploid tissue of equal chronological age.

2. The appearance of an equal number of leaves was demonstrated to be a good indicator of comparable physiological age.

3. A new concept, the physiological growth curve, was introduced to explain many of the results. Leaf number

was substituted for time in the Blackman growth curve formula. The Blackman formula based on time was called the chronological growth curve formula, while the modified formula in which leaf number was substituted for time was named the physiological growth curve formula. The Blackman formula showed that the diploid plants, on the average, were more efficient than the tetraploid plants in producing dry matter throughout the entire experiment while the modified formula showed the reverse. This was expected because the tetraploid plants were slower than the diploid plants in their development.

4. When the data were based on physiological age:

a. total fresh weight and total water content were always higher in the tetraploid plants.

b. total dry weight was always higher in the tetraploid plants.

c. calcium was lower in percentage in the tetraploid plants, however, equal in total amount to the diploid.

d. magnesium results were similar to calcium.

e. potassium percentages were lower in the tetraploid plants during the early cuttings but about equal in the later growth. The absolute amount was higher in the tetraploid.

f. iron percentages were lower in the tetraploid but the absolute amount was equal to the diploid or higher in the tetraploid throughout all the cuttings.

g. phosphorus was lower in percentage in the tetraploid but the absolute amount was equal to the diploid in the early cuttings and higher in the later cuttings.

h. total nitrogen was lower in percentage but higher in absolute amount in the tetraploid.

i. nitrate was lower in percentage in the tetraploid but, in general, higher in absolute amount in the tetraploid.

j. silica percentages were lower in the tetraploid while the absolute amount was equal in both plants.

k. the percentages of the carbohydrate fraction were higher in the tetraploid plants in the early cuttings but lower in the later growth while the absolute amount was higher in the tetraploid.

5. When the data were based on chronological age:

a. total fresh weight and total water content were lower in the tetraploid plants until the 72nd day, followed by a transition which resulted in the tetraploid having the higher values for the remainder of the study.

b. total dry weight was always lower in the tetraploid.

c. calcium percentages were lower in the tetraploid until the 47th day and also between the 56th and 70th days while the absolute amount was always lower in the tetraploid.

d. magnesium percentages were lower in the tetraploid until the 40th day followed by a transition while the absolute amount showed a similar transition on the 72nd day. Both transitions were permanent.

e. potassium percentages were lower in the tetraploid for the initial 44 days while the absolute amount was lower in the tetraploid for the initial 72 days, followed by a permanent transition in both cases.

f. iron percentages were lower in the tetraploid until the 40th day and also between the 44th and 61st days while the absolute amount was lower in the tetraploid until the 70th day.

g. phosphorus percentages were lower in the tetraploid plants until the 54th day while the absolute amount was lower in the tetraploid plants until the 72nd day, followed by a permanent transition in both cases.

h. total nitrogen percentages were lower in the tetra-

ploid plants until the 44th day while the absolute amount was lower in the tetraploid plants until the 72nd day, followed by a permanent transition in both cases.

i. nitrate percentages as well as the absolute amount showed curves which were erratic.

j. silica percentages were lower in the tetraploid until the 39th day and from the 54th day until the end of the experiment, while the absolute amount was always lower in the tetraploid.

k. total sugar percentages were higher in the tetraploid until the 41st day while reducing sugar percentages were higher in the tetraploid until the 45th day, followed by permanent transitions in which the diploid had the higher values. The non-fermentable sugars showed numerous transitions. The absolute amounts of these fractions were always lower in the tetraploid.

6. The data were in full agreement with Schlösser's concept of a "physiologischer Umschlagspunkt." The term "chronological transition point" was suggested to replace Schlösser's term because his term tends one to believe that this point has some physiological significance in the life cycle of the plant being investigated and because the transition stage was reached when the data were compared on a chronological age basis and not on a physiological age basis.

VITA

The writer was born November 11, 1922, in Philadelphia, Pennsylvania. He attended the Leidy School and Sulzberger Junior High School, then went to Central High School of Philadelphia where he was graduated as an honor student in February, 1940.

He entered the Philadelphia College of Pharmacy and Science in September, 1940. He was awarded an undergraduate scholarship each year and in his senior year was a part time laboratory assistant in chemistry. He was graduated in November, 1943, receiving the B. S. degree in chemistry.

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He is the author of:

The chemical relation of the leaf, sheath and stem of blue panicum (*Panicum antidotale* Retz). Plant Physiol. (in press) 1947.